Duplicating has plates on Text & Figures

HYD-260

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

FLOW CHARACTERISTICS OF AN IRVINE 4-INCH BALANCED REGULATOR

Hydraulic Laboratory Report No. Hyd. 260

RESEARCH AND GEOLOGY DIVISION

BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

MARCH 31, 1949

CONTENTS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

Branch of Design and Construction
Research and Geology Division
Denver, Colorado
March 31, 1949

Laboratory Report No. Hyd 260
Hydraulic Laboratory
Compiled by: W. C. Case
Reviewed by: J. W. Ball and C. W. Thomas

Subject: Flow characteristics of an Irvine 4-inch Balanced Regulator.

PURPOSE

1. To determine the flow characteristics of a 4-inch Irvine Balanced Regulator.

2. To appraise the mechanical durability of this water-control device.

CONCLUSIONS

1. Compared to a 4-inch globe valve, the capacity of the 4-inch regulator is greater and the head loss is less (Figure 9).

2. The 4-inch regulator has considerably less capacity than a 4-inch gate valve and the head loss is much greater (Figure 9).

3. The regulator will not function as a shutoff device since there is leakage when the valves are in the closed position.

4. For a given float setting, variable inlet pressure and/or variable discharge from the intake box, the regulator will maintain a head in the intake box only within the limits of the float travel, 9-3/4 inches or the flow capacity of the regulator.

5. The regulator valves will not hunt appreciably when conditions are set for constant flow and constant inlet pressure, as evidenced by the maximum vertical float movement of 3/8 inch observed in the tests made on this regulator.

a. Other factors remaining the same, this vertical float movement will increase if the regulator size (flow) is increased, and/or the depth of water over the regulator is decreased. Excessive float movement will probably shorten the life of the regulator.

b. To minimize wear of the regulator parts, a maximum water surface area and maximum water depth over the regulator should be incorporated into the intake box design and/or stilling baffles should be installed above the valve and below the float.

6. Mechanically, the regulator is unsatisfactory in the following respects:

a. If the setscrew holding the float to the rod should loosen, the regulator will go to the full open position and flooding may result. A positive connection between float and rod should be provided.

b. The hollow sheet-metal float is likely to leak, fill with water, or collapse when submerged. Flooding may result. A non-sinkable-type float should be provided.

INVESTIGATION

Description of the Irvine Balanced Regulator

The Irvine Balanced Regulator is manufactured by the Irvine Balanced Regulator Company, 2729 North Broadway, Los Angeles 31, California. This regulator is designed to give automatic regulation for land irrigation. The common installation is where the regulator controls the flow into an intake box which has a number of lateral deliveries. A general photographic view of the regulator is shown in Figure 1. A sectional view sketch is shown in Figure 2. A sketch of a typical inlet box installation is shown in Figure 3.

The following features of the regulator are given by the manufacturer:

a. The Irvine Balanced Regulator is balanced without the use of springs.

b. The regulator is of rugged bronze construction.

c. The regulator is not affected by the use of standard commercial fertilizers.

d. The design is such that the regulator is easily adaptable to concrete pipe, steel pipe, and transite pipe.

e. The operation of the regulator is independent of inlet pressure because it is balanced. (How it is balanced is described subsequently.) Regulators are in everyday use with from 1 foot of water to 150 psi inlet pressure.

f. The capacity of the regulator is equal to that of any standard gate valve of the same diameter under the same head loss. (The manufacturer appears to be in error and means standard "globe" instead of "gate" valve, as shown by the head loss curves in Figure 9.)

g. The regulator maintains a constant head of water to the laterals regardless of inlet pressure variations. (This "constant" head will vary over the vertical float travel of 9-3/4 inches for the 4-inch regulator as the inlet pressure is varied, and within the flow capacity of the regulator.)

h. The regulator saves water by the elimination of flooding, and thereby reduces erosion. (This statement is not fully correct as explained subsequently.)

i. After 3 years of use no trouble has been experienced by algae attaching to the regulators.

j. The regulator permits variable settings of the float to meet different head requirements on the laterals. When once set, generally requires no further attention.

k. A stock of 4-, 6-, and 8-inch sizes is carried. Larger sizes can be made upon order. The approximate prices in 1947 were as follows:

4-inch	$33
6-inch	43
8-inch	75

There is an additional charge of $5 per valve for steel pipe connections. The manufacturer claims there are approximately 1,500 regulators in use on California ranches.

Referring to Item h above, flooding is not impossible. The float is attached to the float rod by means of a single set screw with no jam nut or other locking device. If this setscrew becomes loose, the float will no longer control the regulator valves which will go to the full open position. Flooding may result. The float rod should have a number of through holes for various head settings, and a bolt or tapered pin used to set the float to the rod, thus giving a more positive connection.

On the regulator tested the thread length on the valve stem for attaching the outside valve was too long (Figure 2). The sharp edges of the thread scraped on the inside of the valve stem guide and might cause sticking or rough action of the valve stem.

The linkage end of the valve stem travels in an arc of a circle (Figure 2). This causes poor sealing of the valves because they do not seat squarely. To provide the best valve seating the valve stem should be perpendicular to the valve lever arm when the valves are closed. The design of the regulator makes this setting impractical since the maximum valve opening would be greatly decreased; however, this setting could be obtained by altering the linkage. The valve wide-open stop is where the linkage arm, attached to the valve stem, contacts the value body. The valve face consists of a rubber-type ring bonded to the valve head to aid sealing.

As discussed in the Test Results section of this report, the forces on the two regulator valves are considerably unbalanced. In the writer's opinion, the word "balanced" in the name Irvine Balanced Regulator connotes that the buoyant force of the float balances out the unbalanced force created by the water pressure-momentum forces on the two valves. However, the forces on the two valves are partially balanced. The two second-class levers incorporated into the regulator linkage provide a variable mechanical advantage from 2.6 to 19.4, depending on the position of the float (Figure 4). The dimensions of the cylindrical, hollow, sheet metal float are 7.89 inches in diameter and 6.07 inches high. Therefore, when the float is completely submerged, it provides a maximum buoyant force of 10.74 pounds. This maximum buoyant force multiplied by the mechanical advantage at various float (valve) positions gives the maximum force that the float can provide to the valve stem.

Test Procedure

A schematic diagram of the test setup is shown in Figure 5. A general view of the intake box used in this study is shown in Figure 6. Figure 1 shows a closeup view of the regulator installed on the 12-inch inlet pipe. The relationship between valve opening and float travel is shown on Figure 7. Curves of flow versus head loss across the regulator were obtained for six different openings of the regulator valve; namely, 20-, 40-, 60-, 80-, 90-, and 100-percent float travel from the closed valve position. For each curve, the float rod was locked in one of the above-mentioned positions of float travel. The water flow was measured by a calibrated 6-inch venturi meter. The head loss upstream tap was placed about 2 feet from the regulator in the 12-inch pipe (Figure 6) and therefore, the head loss includes the 12-inch to 4-inch 90° turn loss.

Test Results

The regulator capacity curves of flow (Q^2) versus head loss (psi) across the regulator at six different float travel positions (different valve openings) are shown in Figure 8. The head loss with the 4-inch regulator valves full open is compared in Figure 9 with those of a full open 4-inch globe valve and a full open 4-inch gate valve. The regulator has a larger discharge area than a globe valve, thus the lower head loss across the regulator was as expected.

Figure 10 shows the operating characteristics of the regulator when it is regulating near 1-second-foot flow. The curves on this figure illustrate the magnitude of unbalanced force in the regulator valves, and that the float supplies the balancing force. The amount the regulator valves are unbalanced is found by multiplying the float buoyant force (less the linkage weight) times the mechanical advantage of the linkage. As shown on the figure the float is of sufficient size. For example, if the valve stem in some way became stuck at the 6-inch float travel position, the float can supply a maximum force of 200 pounds (top curve) to loosen the valve stem.

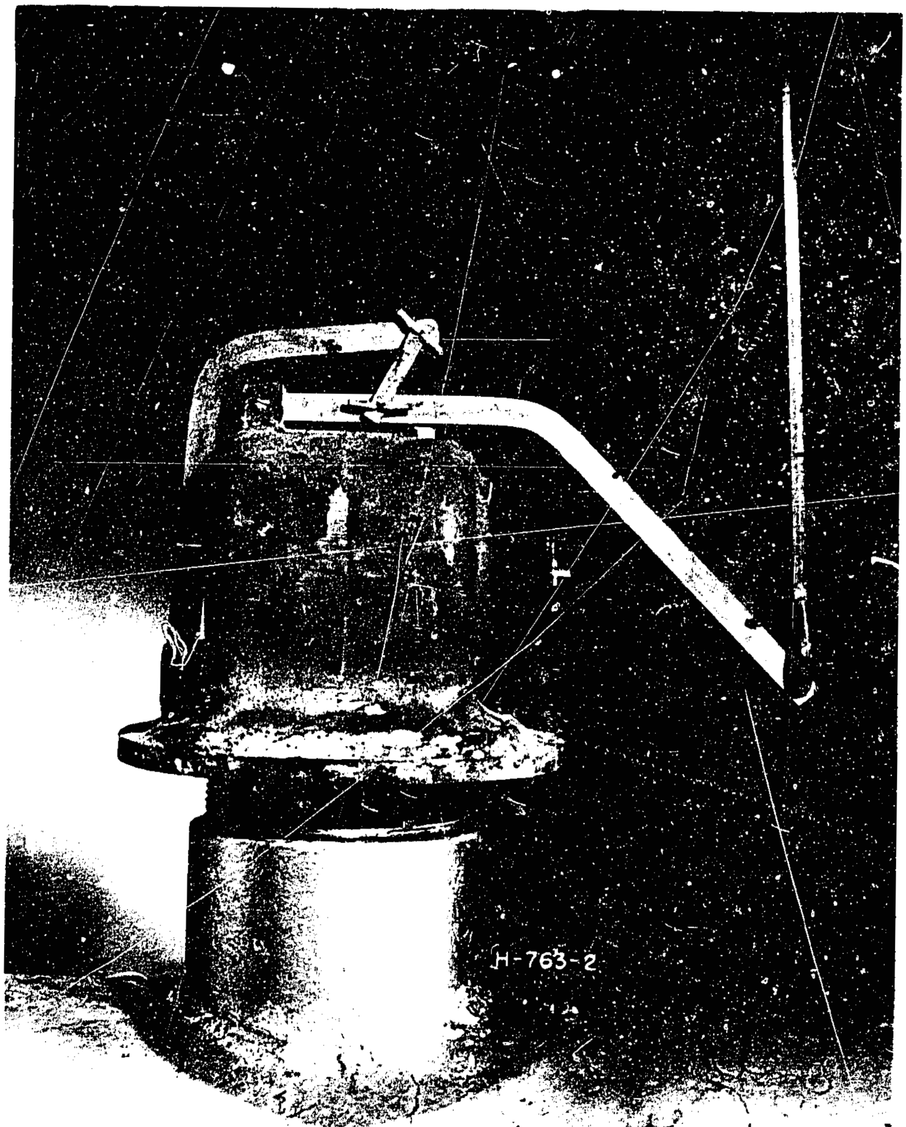
Figure 11a shows the intake box water surface with the regulator in operation at 1-second-foot flow. At any flow within the limits of these tests the maximum and minimum vertical movement of the float and rod was 3/8 and 1/8 inch respectively, with an average movement near 1/4 inch. This vertical movement of the float is caused by the turbulence of the water surface and hunting of the regulator valves. The float movement should be kept to a minimum to alleviate wear of the moving parts.

An attempt was made to use the regulator as a shutoff valve at about 20 psi inlet pressure. The regulator valves would not seal with maximum float buoyant force, and when air bubbles started to appear at the soldered seams of the sheet-metal float (the float top was submerged about 6 inches), the test was discontinued. Thus, in a field installation, if all intake box outlets are closed, it is likely that the regulator will not function as a shutoff valve and flooding will result. When the float becomes submerged, it may leak, fill with water, or collapse. If the float becomes filled with water, the regulator valves will go to the full open position. Flooding around the intake box area may result. Therefore, a nonsinkable-type float should be used.

Two possible locations for cavitation are indicated (Figure 11b); i.e., at the outside valve seat and at the linkage attachment to the valve stem which is in the flow path from the inside valve. Other points of cavitation may possibly be inside the regulator housing. In general, however, regulator inlet pressures in the field will be lower than the pressures used to obtain Figures 9 and 10. Therefore, little or no damaging cavitation is likely to occur.

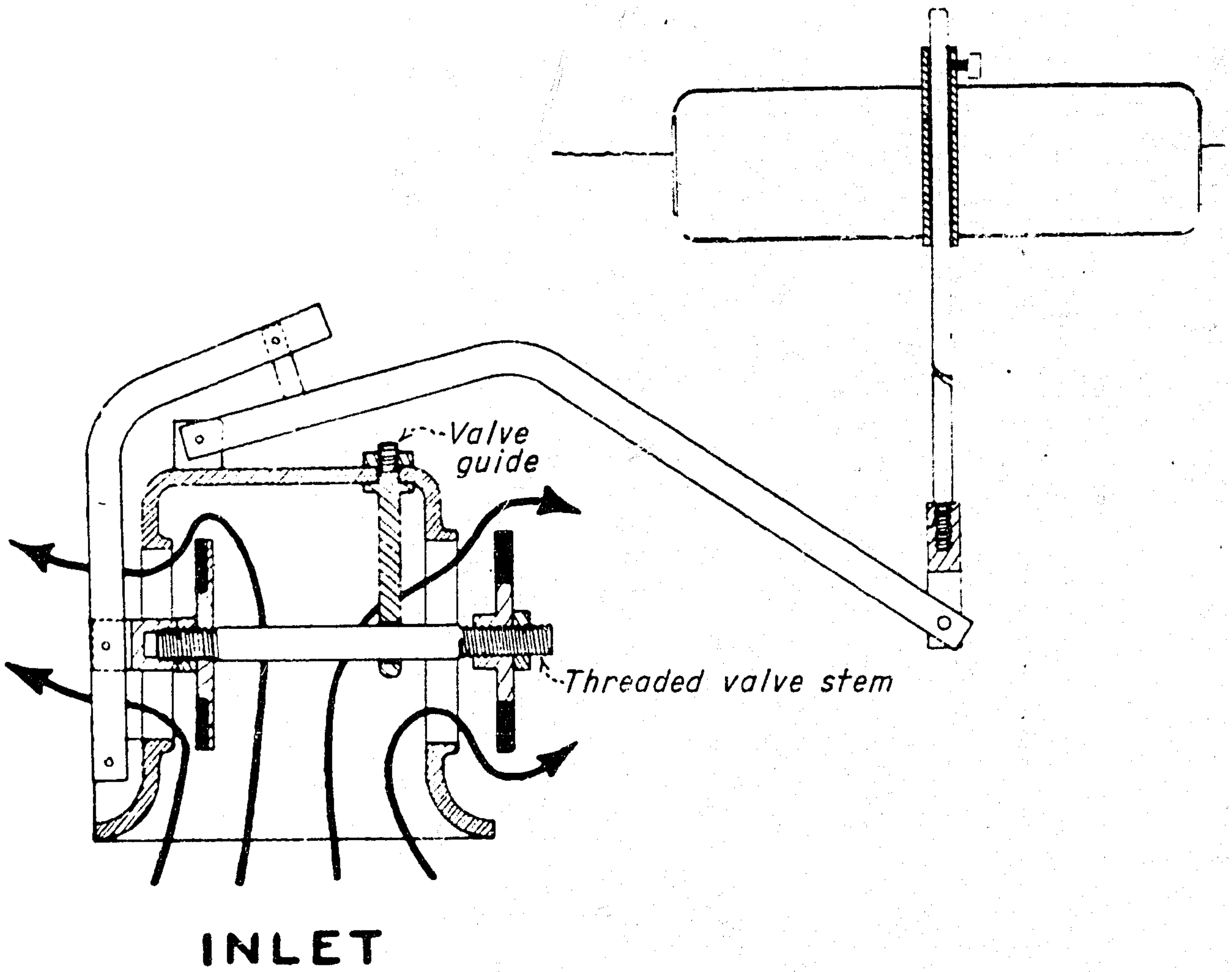
At certain partial valve openings a noise that resembled linkage chatter due to valve hunting was heard; but this noise could have been due to the high-velocity water flow from the submerged regulator valves into the intake box.

Figure 1



General View of Regulator
Installed on a 12 Inch Pipe

FIGURE 2



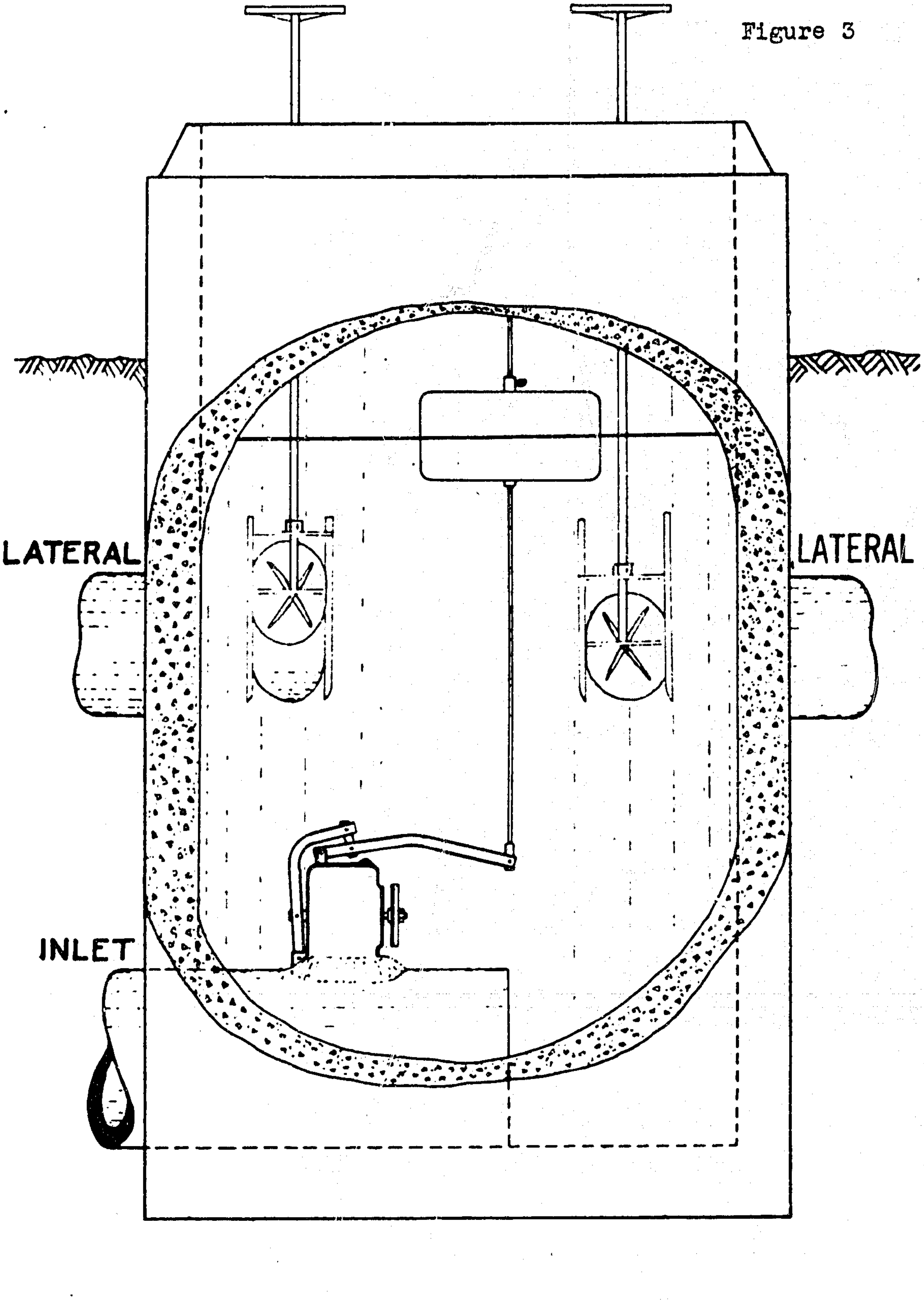
Cross section of

IRVINE BALANCED REGULATOR

for

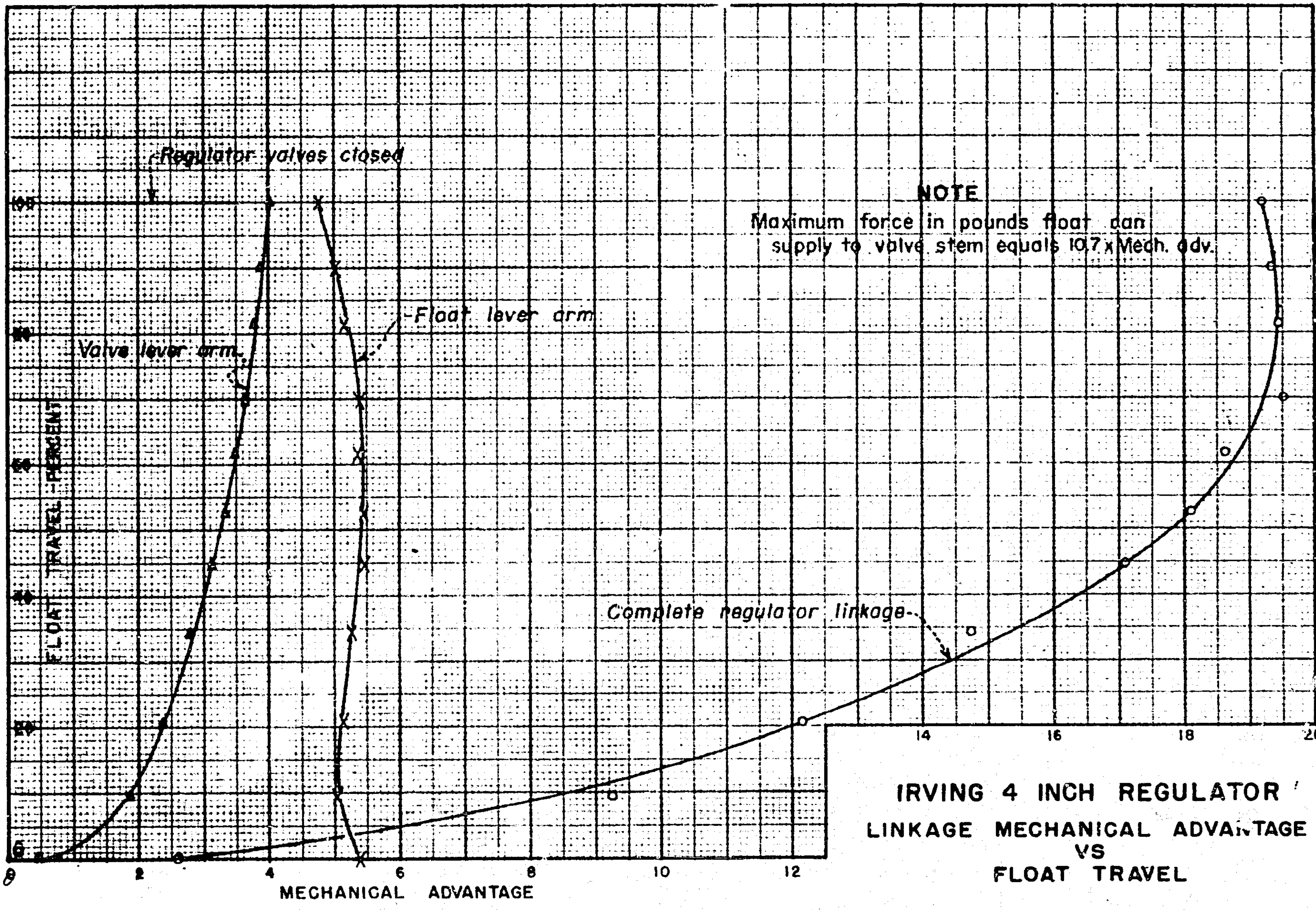
AUTOMATIC IRRIGATION

Figure 3



Holding water level in an intake box with

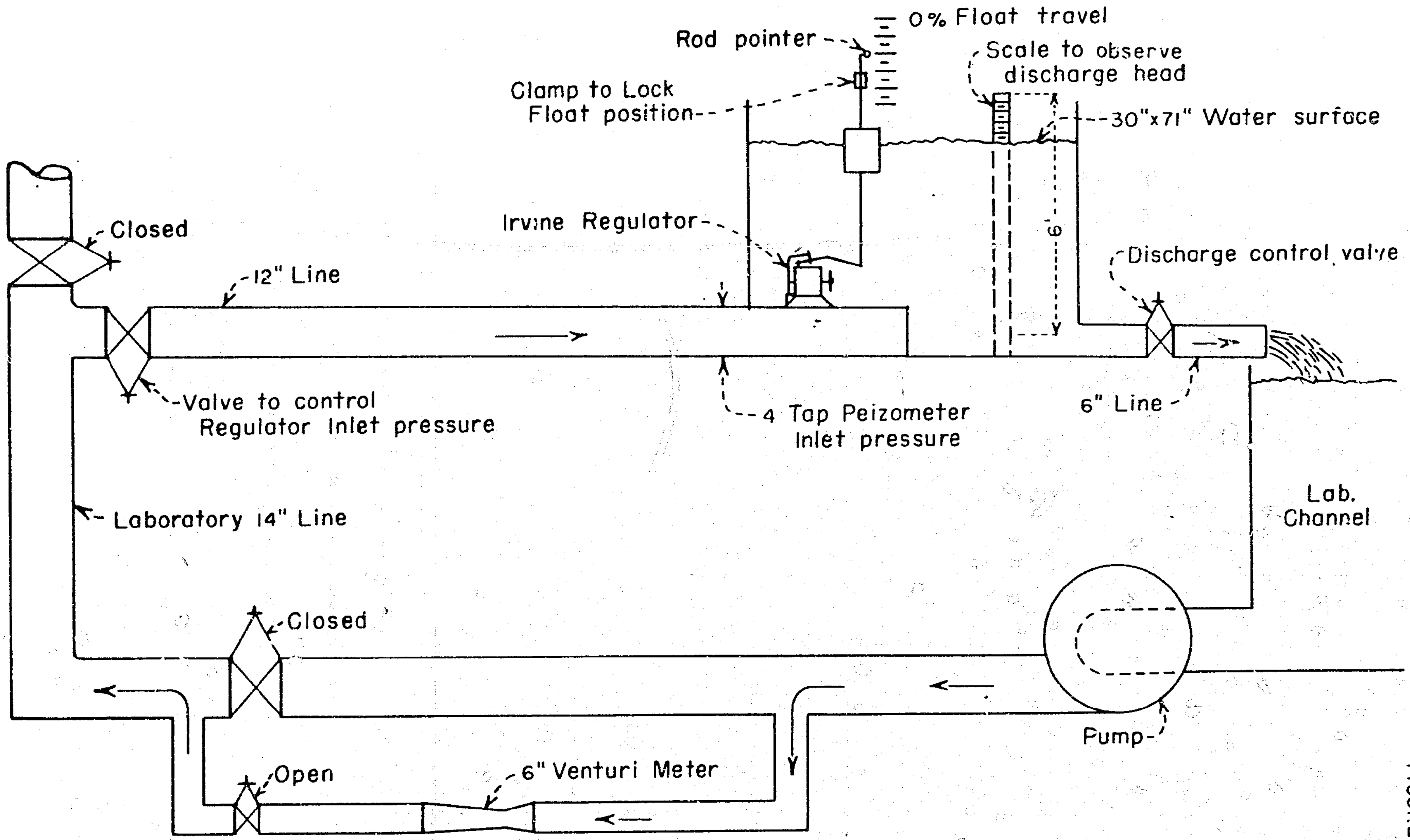
IRVINE BALANCED REGULATOR



IRVING 4 INCH REGULATOR
LINKAGE MECHANICAL ADVANTAGE
VS
FLOAT TRAVEL

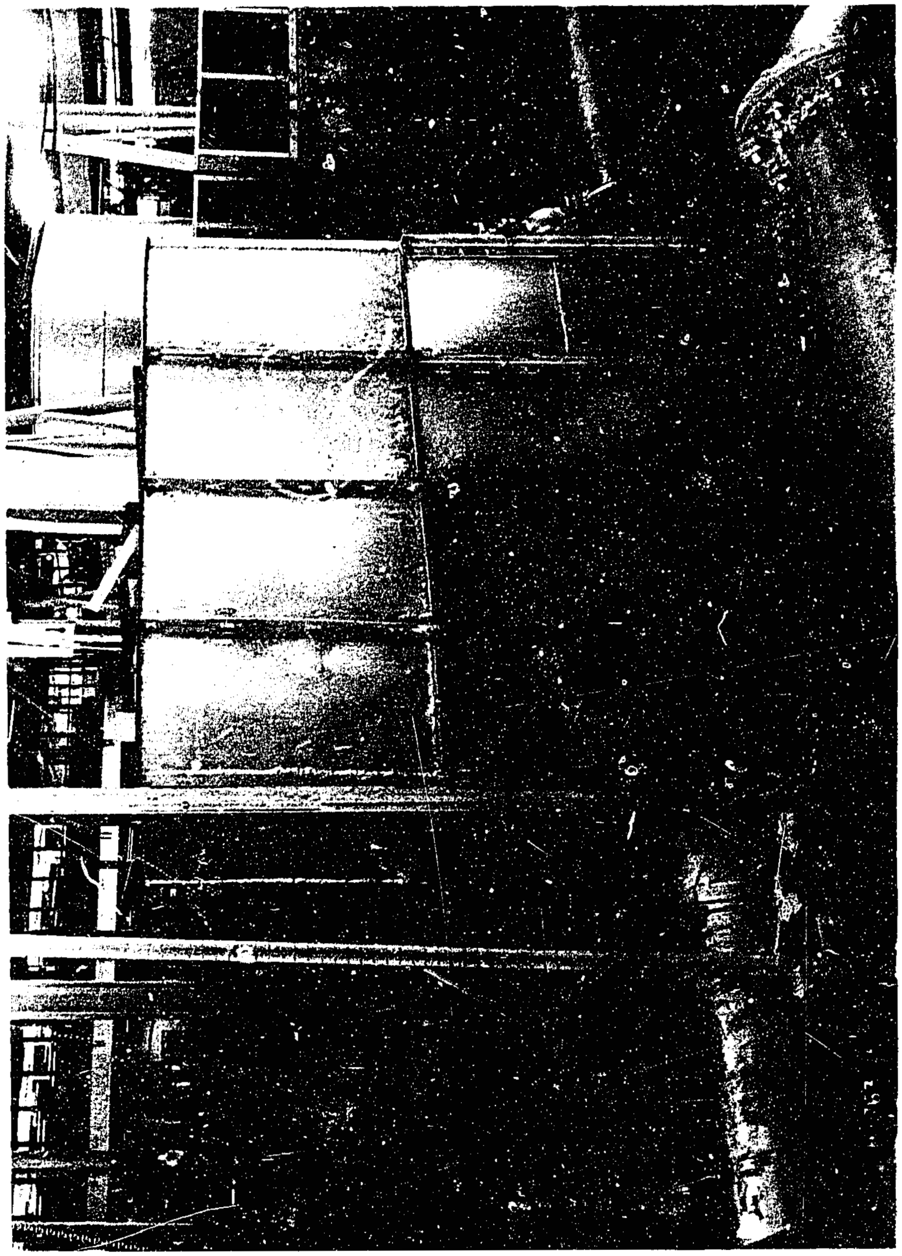
FIGURE 4

FIGURE 5



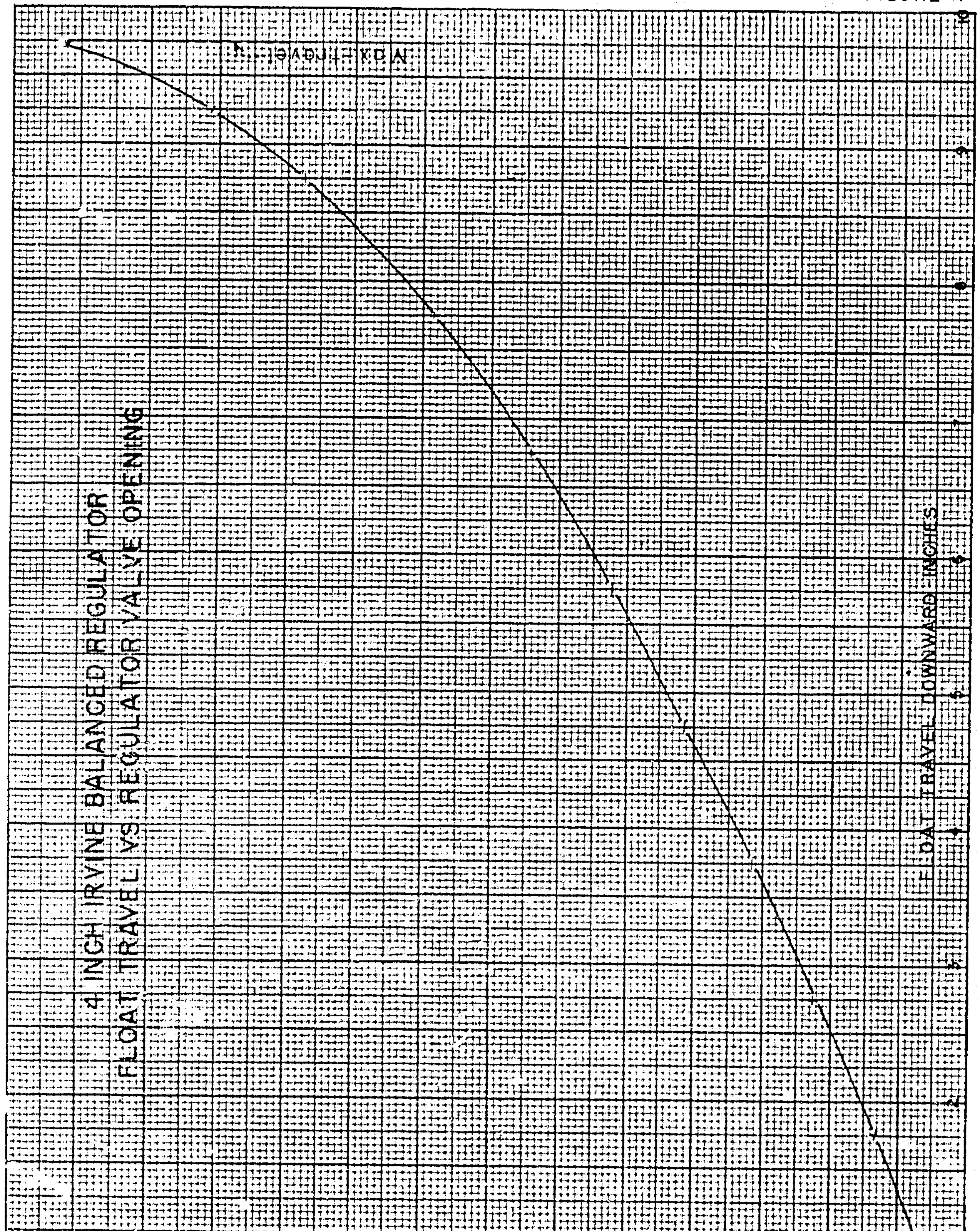
IRVINE 4-INCH BALANCED REGULATOR
SCHEMATIC DIAGRAM OF TEST SET-UF

Figure 6



General View of Intake Box in Test Setup

FIGURE 7



4 INCH IRVINE BALANCED REGULATOR
FLOAT TRAVEL VS REGULATOR VALVE OPENING
FLOAT TRAVEL DOWNWARD INCHES
VALVE OPENING INCHES
MAX. TRAVEL

FIGURE 8

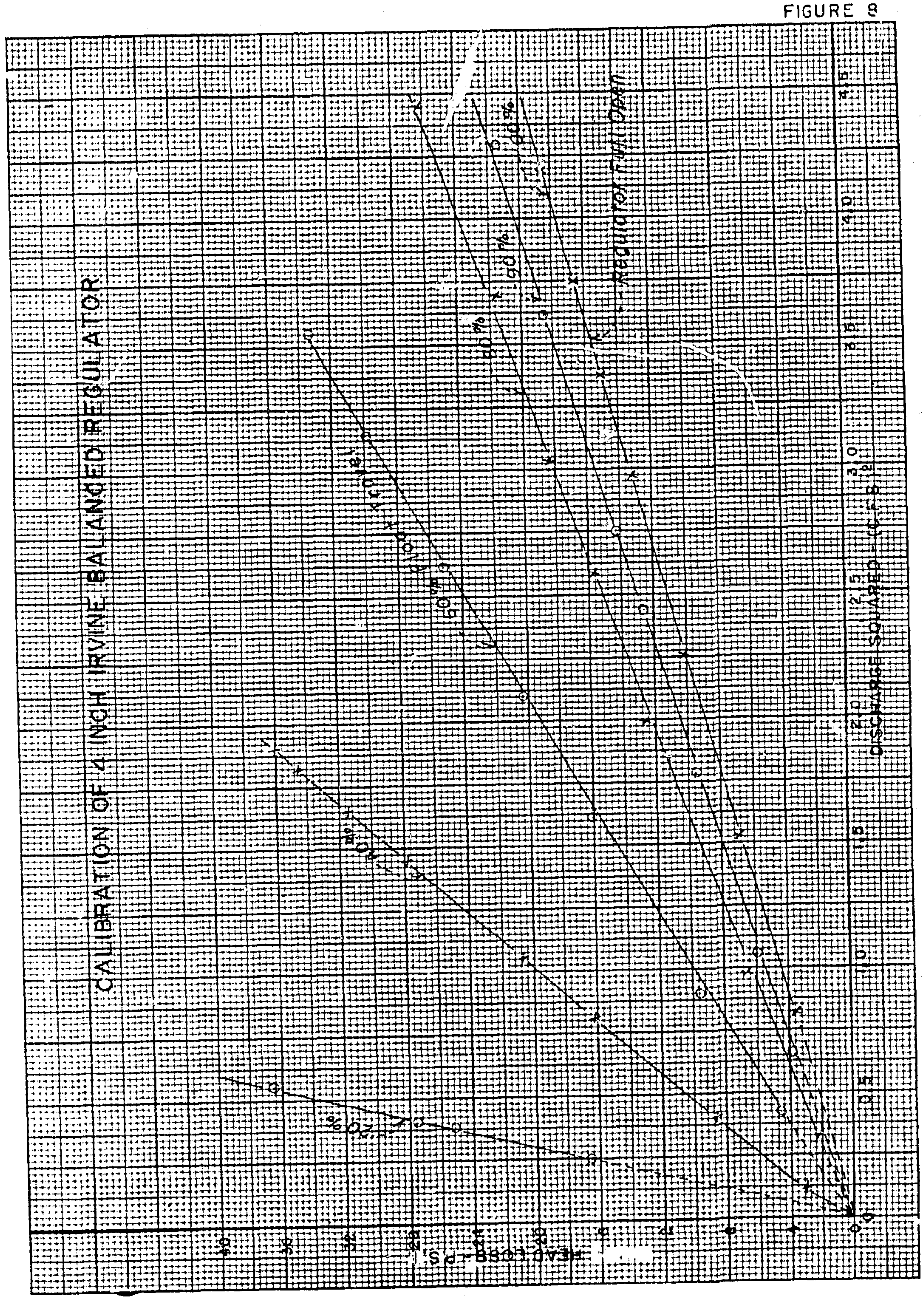
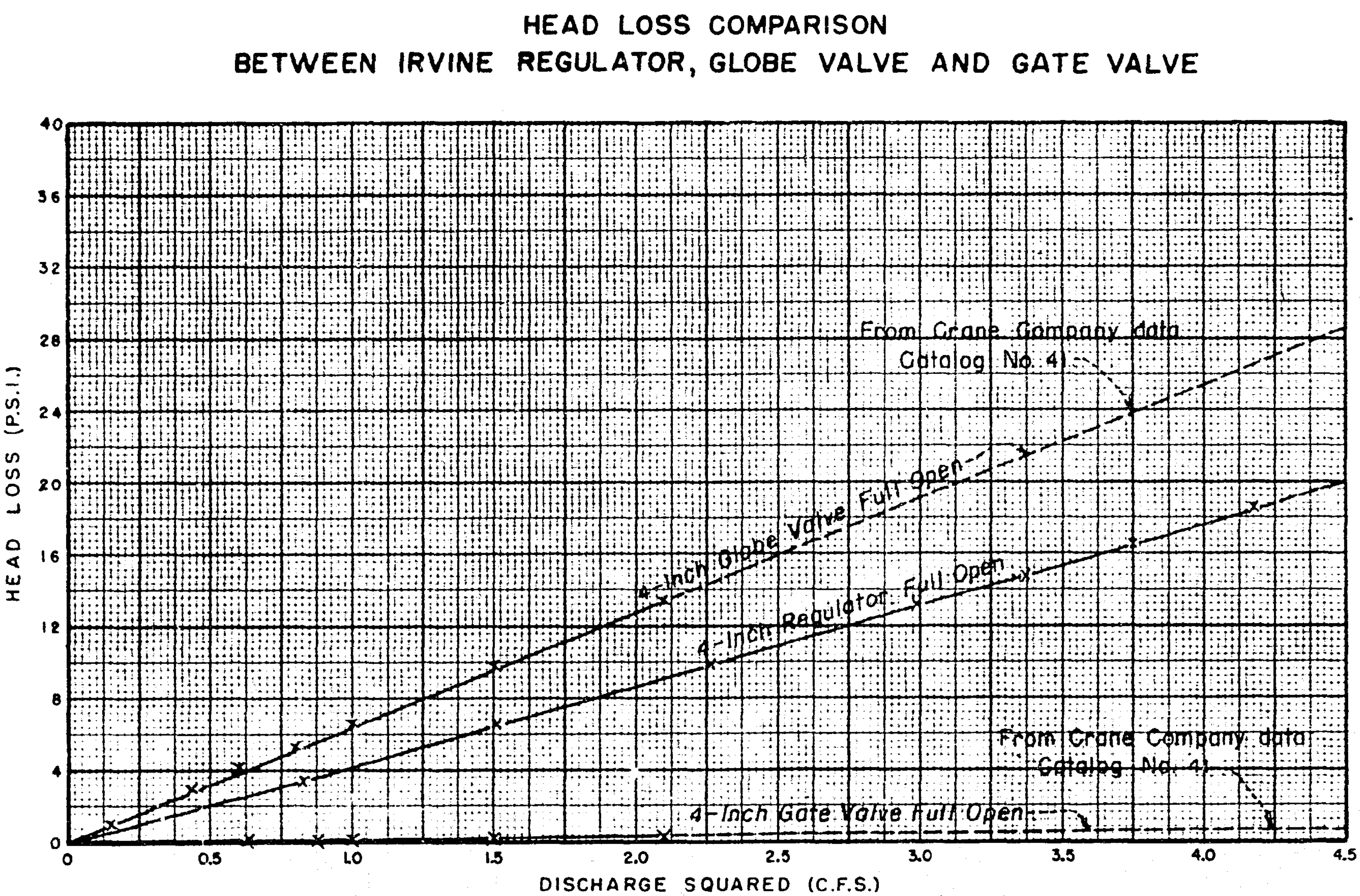

CALIBRATION OF 4 INCH IRVINE BALANCED REGULATOR
DISCHARGE SQUARED - (C.F.S.)²
HEAD LOSS - P.S.I.
Regulator Full Open
20%
40%
60%
80%
90%
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
4
8
12
16
20
24
28
32
36
40

FIGURE 9



HEAD LOSS COMPARISON
BETWEEN IRVINE REGULATOR, GLOBE VALVE AND GATE VALVE
HEAD LOSS (P.S.I.)
DISCHARGE SQUARED (C.F.S.)
0
4
8
12
16
20
24
28
32
36
40
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
From Crane Company data
Catalog No. 4
4-Inch Globe Valve Full Open
4-Inch Regulator Full Open
From Crane Company data
Catalog No. 4
4-Inch Gate Valve Full Open

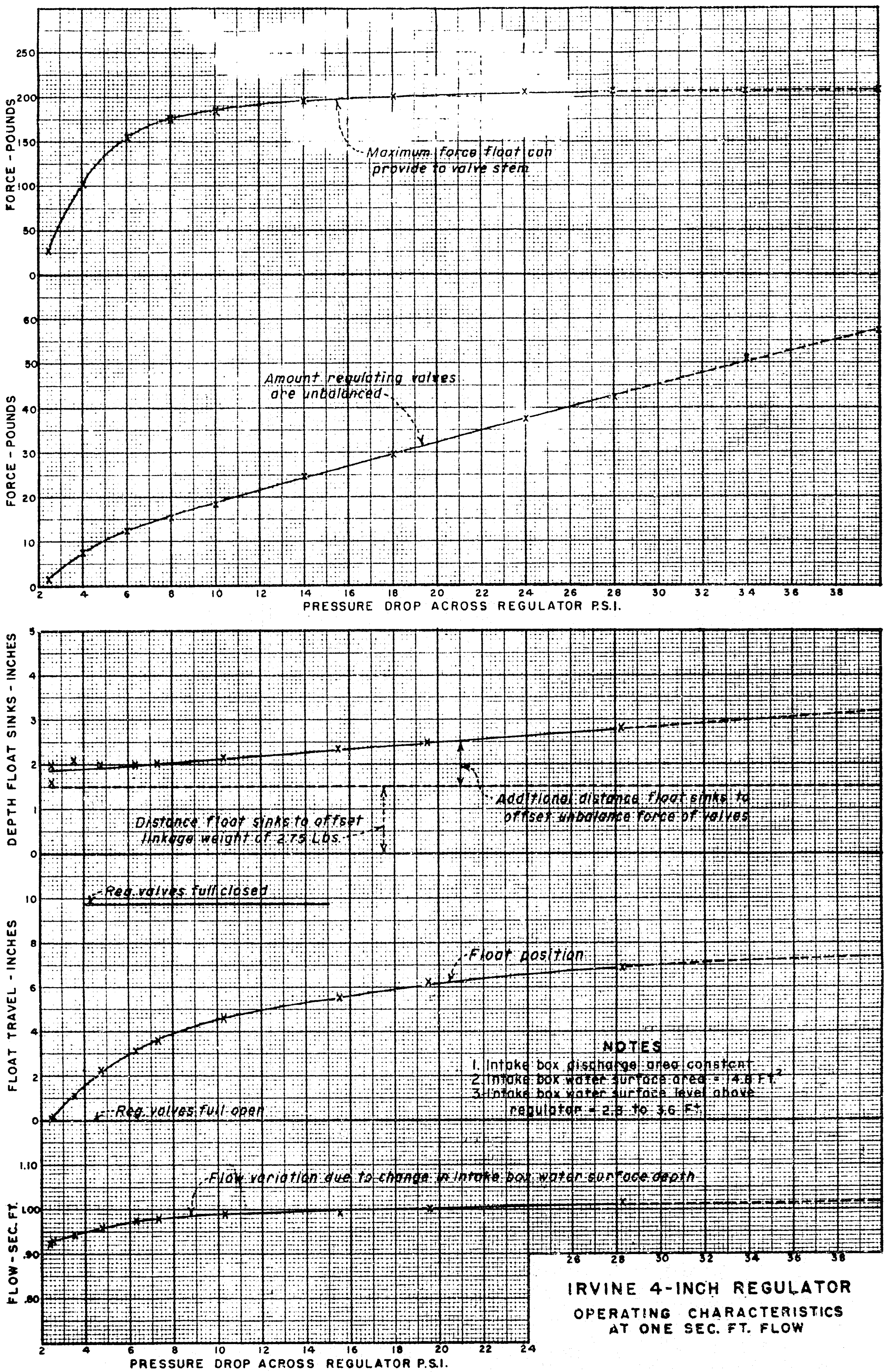
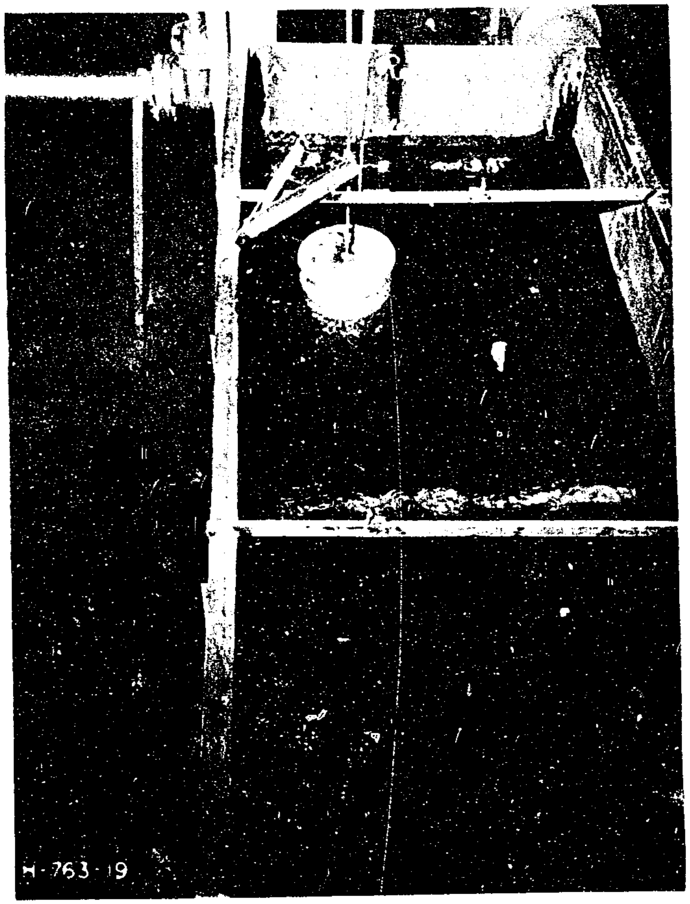


FIGURE 10

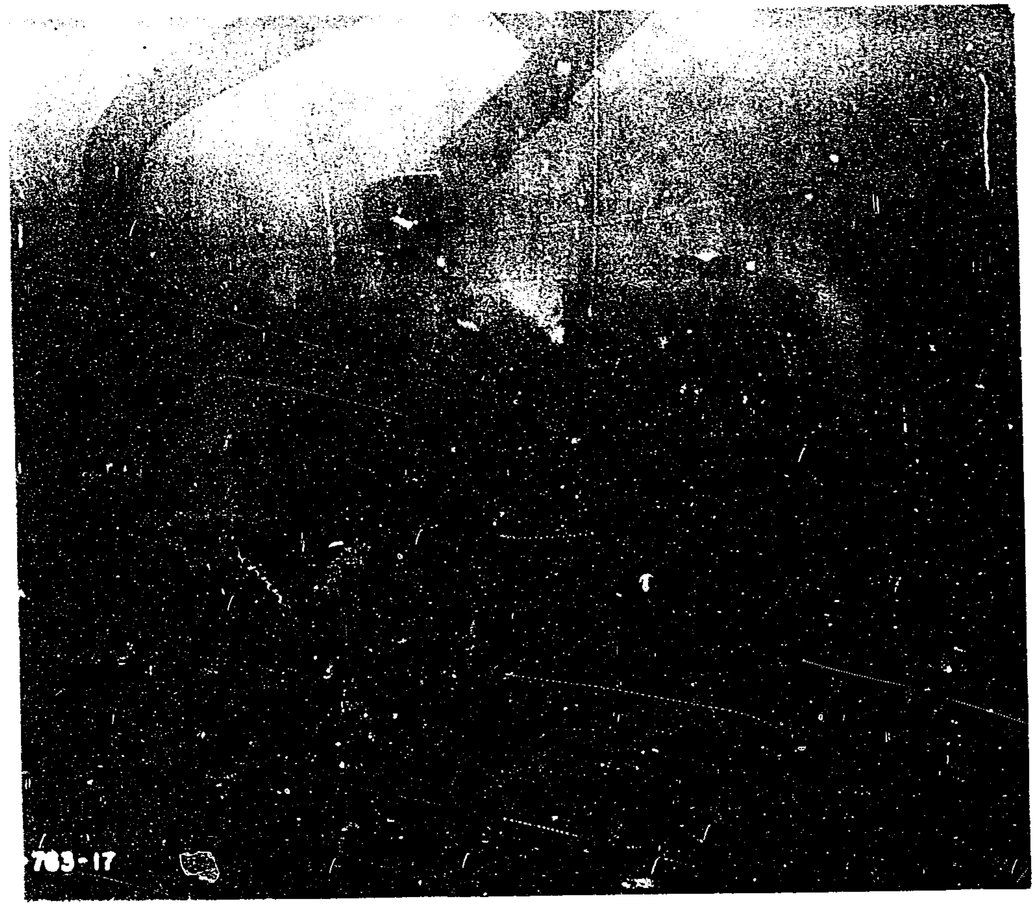
IRVINE 4-INCH REGULATOR

OPERATING CHARACTERISTICS AT ONE SEC. FT. FLOW

Figure 11



a. Intake Box Water Surface with Regulator in Operation at One Sec. Ft. Flow



b. Possible Regulator Cavitation Locations